

TECHNOLOGY UTILIZATION

VALVE TECHNOLOGY

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A COMPILATION



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Foreword

The National Aeronautics and Space Administration has established a Technology Utilization Program for the rapid dissemination of information on technological developments which have potential utility outside the aerospace community. By encouraging multiple application of the results of its research and development, NASA earns for the public an increased return on the investment in aerospace research and development programs.

This publication is part of a series intended to provide such technical information. It is divided into three sections. Section one presents a selection of valves that feature automatic response to various stimuli (thermal, electrical, fluid pressure, etc.). The second section deals with modified valves that have been changed by the addition or redesign of components. These modifications have been made in order to increase initial design effectiveness or to give the item versatility beyond its basic design capability. Section three deals with special purpose valves that have limited application as presented, but could lend themselves to other uses with minor modification.

Additional technical information on individual devices and techniques can be requested by circling the appropriate number on the Reader Service Card included in this compilation.

Unless otherwise stated, NASA contemplates no patent action on the technology described.

We appreciate comment by readers and welcome hearing about the relevance and utility of the information in this compilation.

Ronald J. Philips, *Director*
Technology Utilization Office
National Aeronautics and Space Administration

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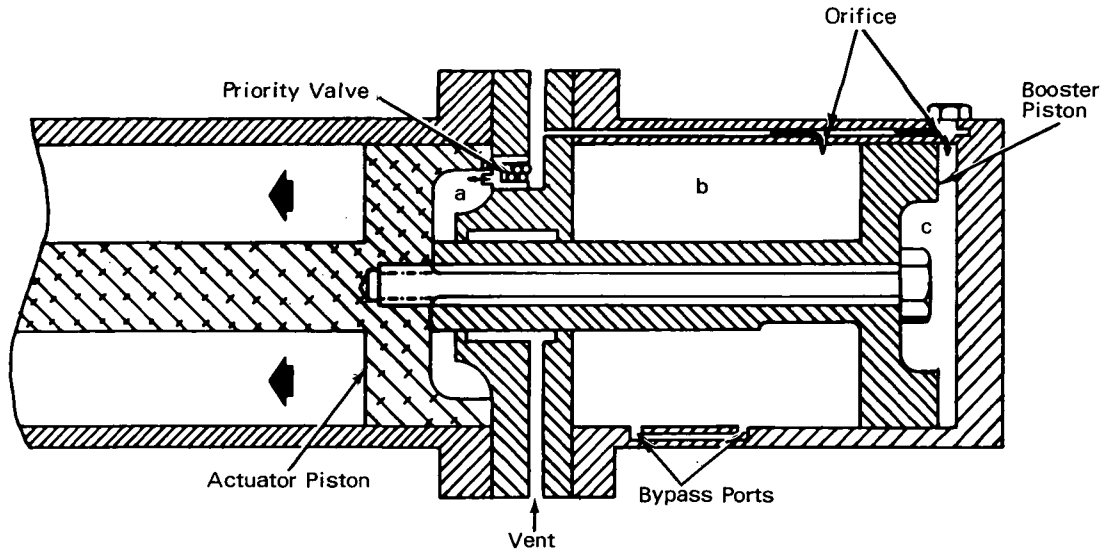
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Section 1. Valves with Automatic Features

ACTUATOR DEVICE SCHEDULES RATE OF VALVE CLOSURE



A preclude actuator is spring loaded to produce a normally open valve, and is pneumatically powered to close the valve. The closure rate is controlled by pneumatic snubber and booster circuitry.

The snubber circuitry (see fig.) schedules the valve closure in order to limit surge pressure. The booster circuitry augments a piston output at or near the point of complete valve closure when additional input torque is required.

The application of closing pressure fills chambers a, b, and c at essentially equal rates. The fill rates are controlled by fixed orifices in chambers b and c, and by a priority valve (variable orifice) in chamber a: The application of pressure starts the valve closure cycle by a force buildup across the actuator piston.

As the actuator piston moves and forces the

valve toward the closed position, the priority valve no longer contacts the actuator piston, and a relatively unrestricted flow of gas is permitted into chamber a. The inlet orifice to chamber b is then covered by the booster piston, thereby initiating a compression cycle in chamber b. This results in a snubbing action on the valve.

Further travel of the valve toward the closed position causes the booster piston to uncover bypass ports between chambers b and c. This equalizes the pressure across the booster piston and terminates the snubbing action.

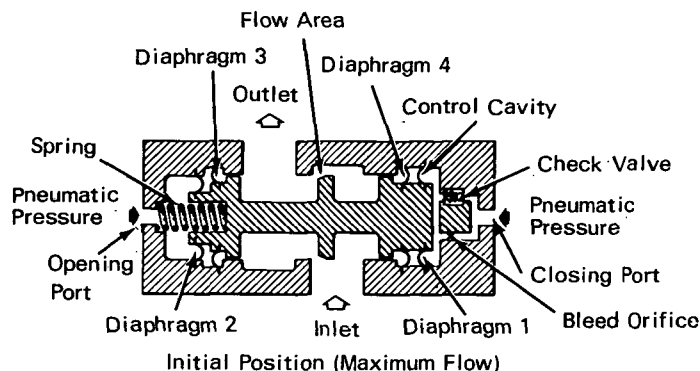
Source: Whittaker Corp.
under contract to
Marshall Space Flight Center
(MFS-1556)

Circle 1 on Reader Service Card.

PNEUMATIC SHUTOFF AND TIME-DELAY VALVE OPERATES AT CONTROLLED RATE

The valve incorporates a metering spool, which moves at constant velocity under pneumatic pressure, and spring compression to achieve uniform flow-area increase.

Fluid flow occurs through the main section of the valve from inlet to outlet. The rate of fluid flow is controlled by changing the flow area as the metering spool is stroked at a uniform rate.

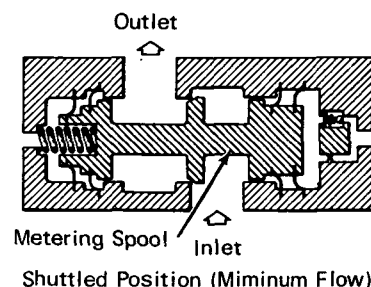


At the start of the operation, the spring (see fig.) holds the spool in the initial position. Pneumatic pressure is applied to the closing port, causing air to flow through the check valve and into the control cavity. The pressure builds up rapidly in the control cavity, exerting a force on diaphragm 1, which moves the spool into its shuttled position. In this position, the flow area is at a minimum. If the desired minimum flow area is greater than zero, a mechanical stop within the valve is required to hold the spool away from its seat. If the minimum flow desired is zero, the seat may act as the stop. To stroke the spool through its metering cycle, pressure is applied at the opening port at the same time that pressure is vented through the bleed orifice at the closing port. Pressure at the opening port exerts a force on diaphragm 2 to shuttle the spool to the open position.

Since the pressure in the cavity around diaphragm 2 is essentially constant, and the force exerted by the spring is also essentially constant over the displacement of the spool, the force on the spool is constant, and a constant gas pres-

sure is produced in the control cavity. As a result, gas flows at a uniform rate through the bleed orifice, and the spool moves at a constant speed.

It is also possible with this arrangement to achieve a time delay prior to the motion of the spool. If the effective area of diaphragm 2 is sufficiently smaller than that of diaphragm 1, and equal pressures are applied in the cavities around the two diaphragms, then the force on dia-



phragm 1 is greater than the force (due to the pressure acting on diaphragm 2 and the spring compression) acting on the left end of the spool. This excess force holds the spool against its seat or stop in the shuttled position. The pressure in the control cavity must be bled down to the point where the opposing forces are equal before the spool can begin to move to the right. The time required to bleed the control cavity to this lower pressure is the time delay desired. Diaphragms 3 and 4 are used to isolate the controlled fluid from the controlling fluid and to balance the fluid-line pressure forces on the spool.

Diaphragm areas, control cavity volume, and bleed-orifice size may be varied to give any desired combination of time delay and spool travel time.

Source: J. L. Horning and L. E. Tomlinson of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-602)

No further documentation is available.

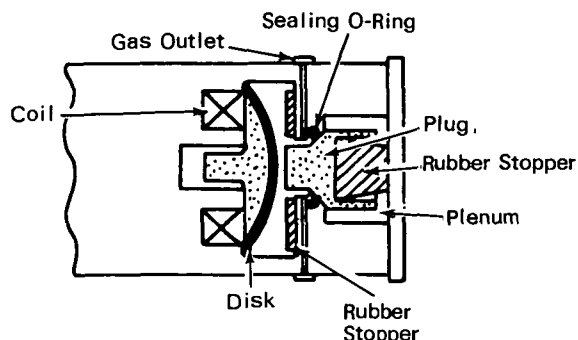
EDDY CURRENT DISK VALVE

The new device is a quick-opening, intermittent flow valve that requires a small amount of electrical energy to open, and closes by the restoring action of a rubber stop. The valve opens in less than 100 μ s, takes only 10 J of energy, and has survived 50,000 operations without damage. The basic losses are due to ohmic heating in the coil and in the disk. By varying the strength of the electrical coil and the restoring force of the rubber stopper, this design can be adapted to maintain the valve in an open position as long as energy is applied to the coil.

The valve is operated by discharging an energy storage capacitor into the coil. Eddy currents induced in the disk cause it to be accelerated into the plug. The plug is driven off the sealing O-rings and compresses the rubber stopper. This permits gas to flow from the plenum chamber to the gas outlets. The compressed rubber stopper restores itself and the plug to their original positions, shutting off the gas flow.

In this design, the disk is allowed to accelerate to its terminal velocity before impacting the sealing plug. This technique is in contrast to similar

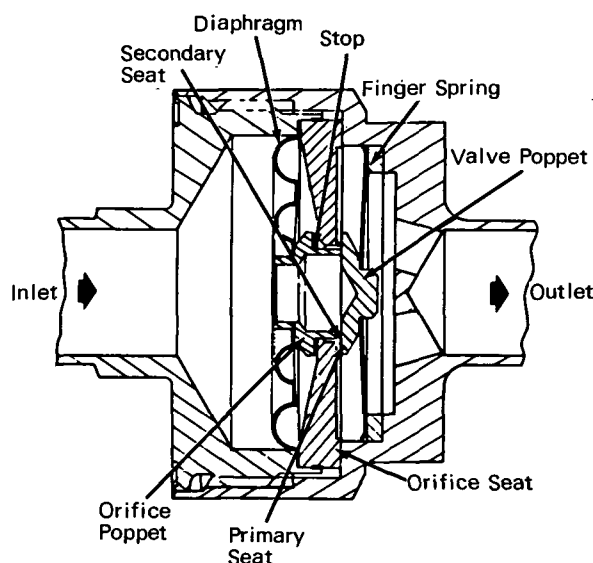
valves in which the disk itself opens a seal during initial disk movement. The described arrangement allows a longer time for the magnetic forces to act and provides a relatively higher force coil impedance, which can be matched to the energy storage capacitor.



Source: A. V. Larson and J. P. Tinkham of
General Dynamics/Convair Div.
under contract to
Lewis Research Center
(LEW-10123)

Circle 2 on Reader Service Card.

LOW LEAK RATE POPPET-AND-SEAT CHECK VALVE



Valve leakage due to contaminant entrapment and chattering has been effectively minimized by a metallic poppet-and-seat check valve designed for use in extreme environmental and fluid temperature conditions. Operation under these conditions normally requires that the opening distance of the valve be very small. Under certain resonant conditions, this mode of operation may cause the valve to chatter, which in turn causes erratic operation of the valve and excessive wear on the valve sealing surfaces. The small opening distance also contributes to contaminants being trapped between the sealing surfaces, preventing the valve from closing completely. Both characteristics contribute to valve leakage which may be unacceptable for the particular application.

Two design features of the poppet-and-seat check valve (see fig.) eliminate these problems.

First, contaminant entrapment problems are minimized by the double seat and poppet configuration which permits an opening arrangement that can tolerate contamination of a certain particle size without degradation of the valve sealing capability. The arrangement consists of the primary sealing point between the fixed orifice seat and the valve poppet, and the secondary sealing point between the orifice poppet and the valve poppet. Upstream of the valve orifice is a flexible convoluted metal diaphragm attached to the orifice poppet. This feature permits movement of the secondary seat and acts as a seal to prevent gas flow except through the central hole in the secondary seat.

Second, downstream of the valve orifice is the finger spring which exerts a force against the valve poppet, tending to keep the valve in a closed position. This finger spring is used to minimize chatter. It has a low mass and a natural frequency above the range which causes chatter of the poppet. Should chatter occur, the double seat configuration makes it possible for all excessive wear to take place on one sealing interface.

Source: D. E. Whitten of
Bendix Corp.
under contract to
Manned Spacecraft Center
(MSC-13587)

Circle 3 on Reader Service Card.

PRESSURE EQUALIZATION VALVE

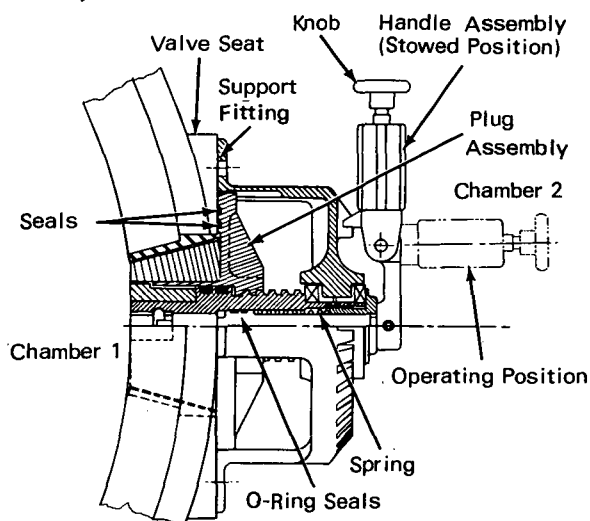
This valve enables the equalization of the pressure existing in two joined chambers when the pressure must be separately maintained in one mode but quickly equalized for a succeeding mode. Applications include emergency relief valves for decompression chambers, underwater airlocks for

oceanographic chambers, and tunnel or subway construction airlocks.

To equalize the pressures of chambers 1 and 2 (see fig.), the handle assembly is released from the stowed position and moved $\pi/2$ rad (90°) to the operating position. The knob is then turned counterclockwise, backing the plug assembly away from the valve seat (approximately 7 turns brings the plug assembly against its stop in the fully open position). To reseal and seal the valve in the closed position, the knob is rotated clockwise until the plug assembly engages the valve seat. The handle assembly is then returned to the stowed position, locking the valve in the closed position.

Source: R. M. Nixon and W. W. Brooker of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-11684)

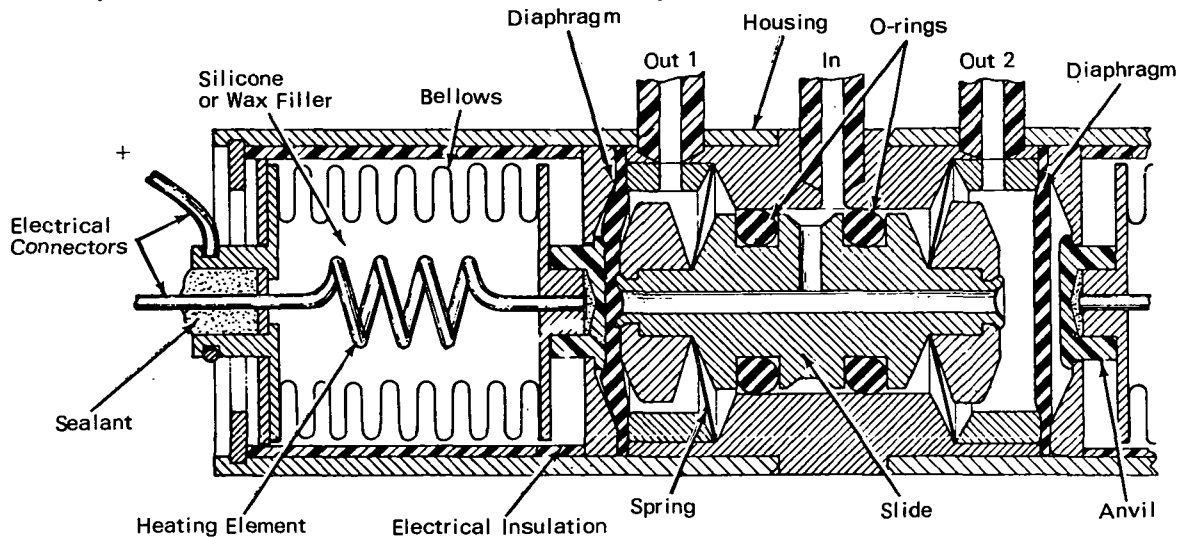
Circle 4 on Reader Service Card.



AN ELECTROTHERMALLY ACTUATED MICRO VALVE

The device described is a microminiature valve which requires power only during actuation and can be used as an on-off or single inlet to alternately selected outlets.

Electrical current applied to the conductor and bellows causes the wax to expand and push the anvil against the diaphragms until the springs snap over center. This action causes the slide



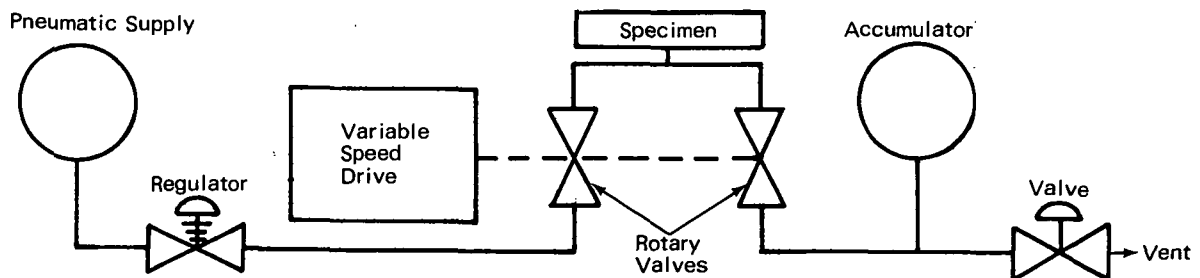
The innovation consists of a slide action valve (see fig.) housed between two-way bellows assemblies. The figure illustrates a valve with one inlet and two outlets, although the configuration lends itself to multiport designs. The slide is held to the left or right by belleville springs, and at each end is a diaphragm which is pressed between the end of the slide and the anvil (depending on the direction in which the slide was last pushed.).

to move until the right end seats against the diaphragm at the right end of the valve, stopping flow at outlet 2 (flow at outlet 1 continues).

Source: R. Sipman and K. W. Charlton of Caltech/JPL under contract to NASA Pasadena Office (NPO-10730)

Circle 5 on Reader Service Card.

PNEUMATIC PRESSURE OSCILLATOR



The pneumatic pressure oscillator exposes pneumatic systems to transient conditions, enabling designers to study system response under dynamic conditions. Optimum system parameters of line

length, line diameter, and configuration can be determined more accurately than by the previous method of using a single pressure transient.

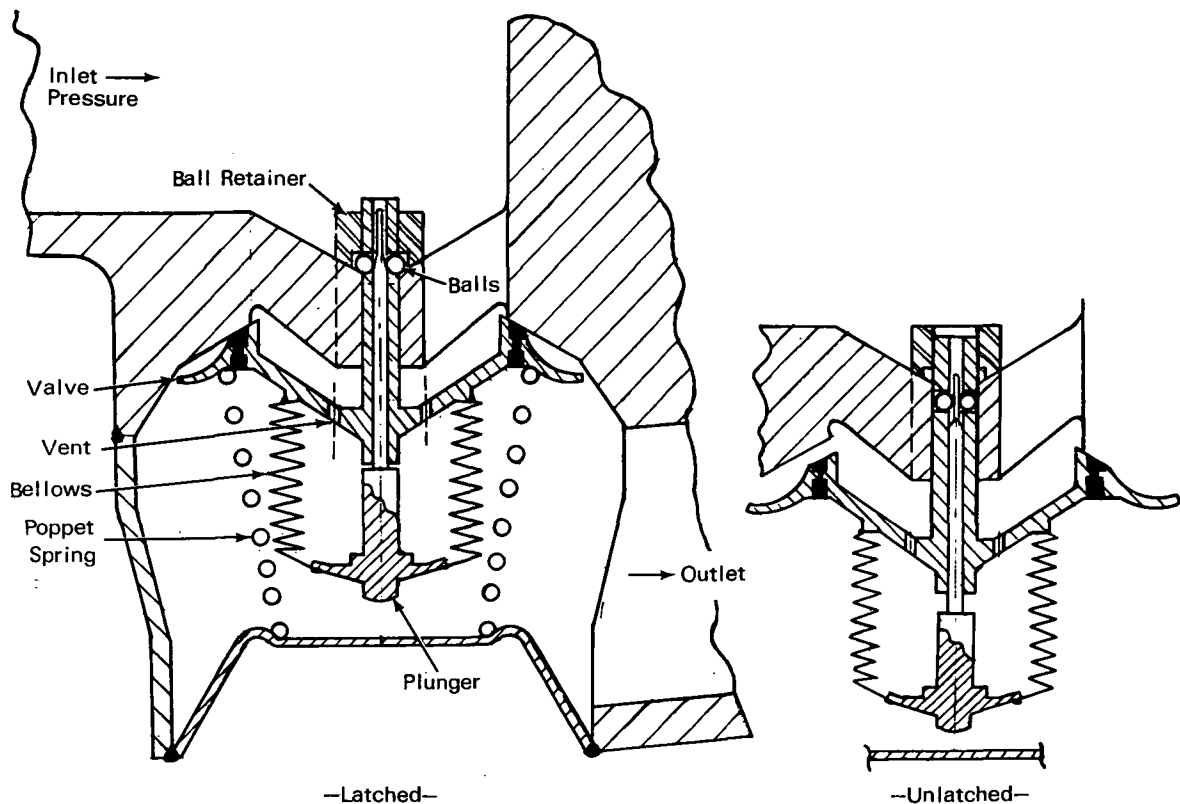
A variable speed drive (see fig.) operates two

coupled rotary valves with an adjustable rotational angle between their ports. The adjustable angle provides a selectable pressure waveform. A valve in the vent line adjusts the average value of the oscillations to provide a static pressure reference. The period of the pressure waveform is controlled by adjusting the variable drive speed.

Source: K. D. Skjerven,
G. Acquistapace, and
R. R. Walker of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15889)

No further documentation is available.

CHECK VALVE LATCHED BY BACK PRESSURE



A new check valve uses back pressure rather than spring pressure to latch it in the closed position when downstream (outlet) pressure exceeds a safe level. The valve has application wherever backflow cannot be tolerated, due to vaporization or valve chatter problems.

During valve operation (see fig.), as back pressure increases, the bellows compresses and moves the tapered shaft of the plunger, forcing the balls from their normal position in the valve stem to a locked position on the inclined surface of

the valve countersink. As the inlet pressure is increased, the counter force expands the bellows, which retracts the plunger shaft, permitting the balls to unlatch the valve and return to their normal position in the valve stem.

Source: N. E. Cahill of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-90991)

No further documentation is available.

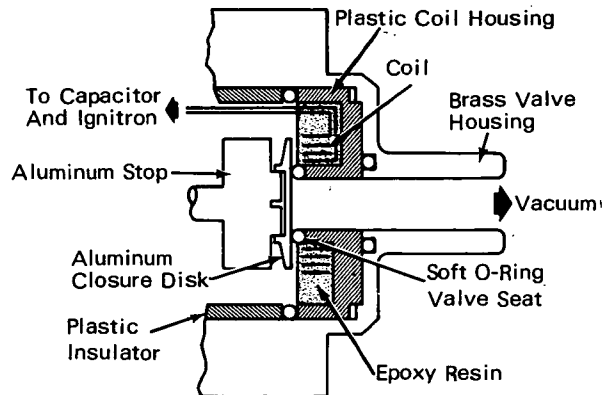
GAS INJECTION VALVE OPERATES AT HIGH SPEED

A new type of fast acting gas valve incorporates a lightweight closure disk that is forced away from the valve seat when an electromagnetic coil is momentarily energized. The disk immediately rebounds from a stop back onto the seat.

Many plasma acceleration experiments require the injection of a short pulse of gas into a vacuum chamber. This valve is needed because it can be opened for a brief and controllable period, usually on the order of 100 μ s.

The closure disk, made of aluminum, is held on the O-ring valve seat by a gas pressure of 100 kN/m² (1 atm) or more. The O-ring, consisting of a soft silicone elastomer, is adhesively attached to the plastic coil housing. The coil, consisting of 4 turns of 0.7 mm x 4 mm ribbon, is potted in epoxy resin for electrical insulation and mechanical positioning. Insulated coil leads from the valve chamber are connected across an ignitron switch and an 8.5 μ F capacitor, which is normally charged to 7.0 kV. The current through this circuit rings with a frequency of 55 kHz and is damped out in 90 μ s. The valve is normally positioned sideways, and the disk is prevented from creeping away from the seat by a short cylinder that protrudes from the seat by a short cylinder that protrudes from the aluminum stop into a recess in the disk. An adjustable gap between the stop and the disk is normally set at 0.3 mm.

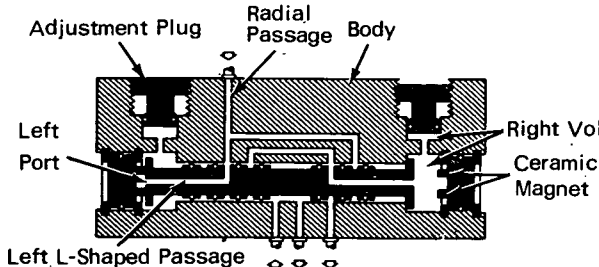
Upon discharge of the capacitor through the coil, the disk is electromagnetically accelerated toward the stop, opening the valve for about 100 μ s and admitting a burst of gas into the vacuum chamber. On striking the stop, the disk rebounds onto the O-ring, keeping the valve closed until the ring becomes decompressed (a period of 300 to 400 μ s). The valve reopens for a briefer period as a result of decompression of the O-ring; however, the first closure period is long enough for most plasma measurements.



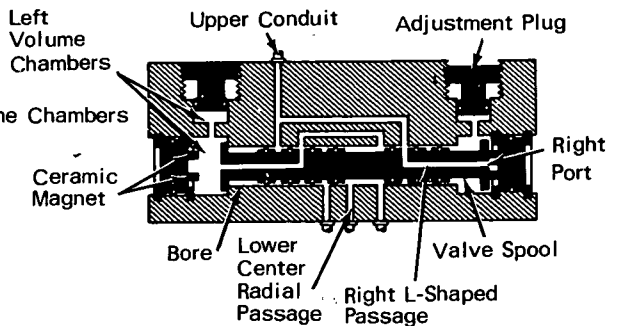
Source: R. S. Lowder and F. C. Hoh of Advanced Kinetics, Inc. under contract to NASA Headquarters (HQ-49)

Circle 6 on Reader Service Card.

SPOOL VALVE CYCLES AT CONTROLLED FREQUENCY



This spool valve sets its own cycle of applying and releasing preselected pneumatic pressure over long periods. It is therefore useful for stimulating vascular activity in bed-confined patients



or in astronauts in the weightless condition during extended space flight. The valve impresses and removes, in a cyclic fashion, pneumatic pres-

sure to simulate the pressure exerted on the body's blood vessels in normal terrestrial activity.

The spool valve, made from magnetic material, is operated from any source of sufficient continuous pneumatic pressure. It employs a series of ports and passages that register and lose registry in a switching manner at a preselected cyclic rate, sequentially inflating and relieving inflatable sleeves that cover the subject's limbs.

With the spool valve in the position shown in the upper figure, metered fluid enters the upper conduit and passes into the upper radial passage, through the left L-shaped passage and into the left chambers. At this time, the right chambers are vented through the right L-shaped passage and out the lower right radial passage. The left adjusting plug is not threaded into the valve body as far as the right adjusting plug. This creates a volumetric difference between the right and left chambers, and the difference is adjustable, allowing the spool valve to remain for a longer period in either the left or right position. Fluid continues to flow into the left chambers until pressure builds to a force greater than the combination of the force of the

left magnet on the valve and the frictional forces between the valve and valve bore. The valve then unseats and moves to the right where it is attracted by the right magnet, which provides a snap action closure in the right position, as shown in the lower figure.

In the right position, fluid flows into the upper radial passage and through the right L-shaped passage into the right chambers. At the same time, the left chambers are vented through the left L-shaped passage and through the lower center radial passage. Pressure builds in the right chambers to a point that unseats the valve and causes the above described action to take place in the reverse (or left) direction.

Regulation of pressure from the external source, positioning of the adjusting plugs, and magnet selection together afford a wide variation in cyclic timing and speed of closure in either direction.

Source: D. E. Van Arnam and K. W. Charlton of
Bechman Instruments, Inc.
under contract to
Manned Spacecraft Center
(MSC-143)

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Section 2. Modified Valves

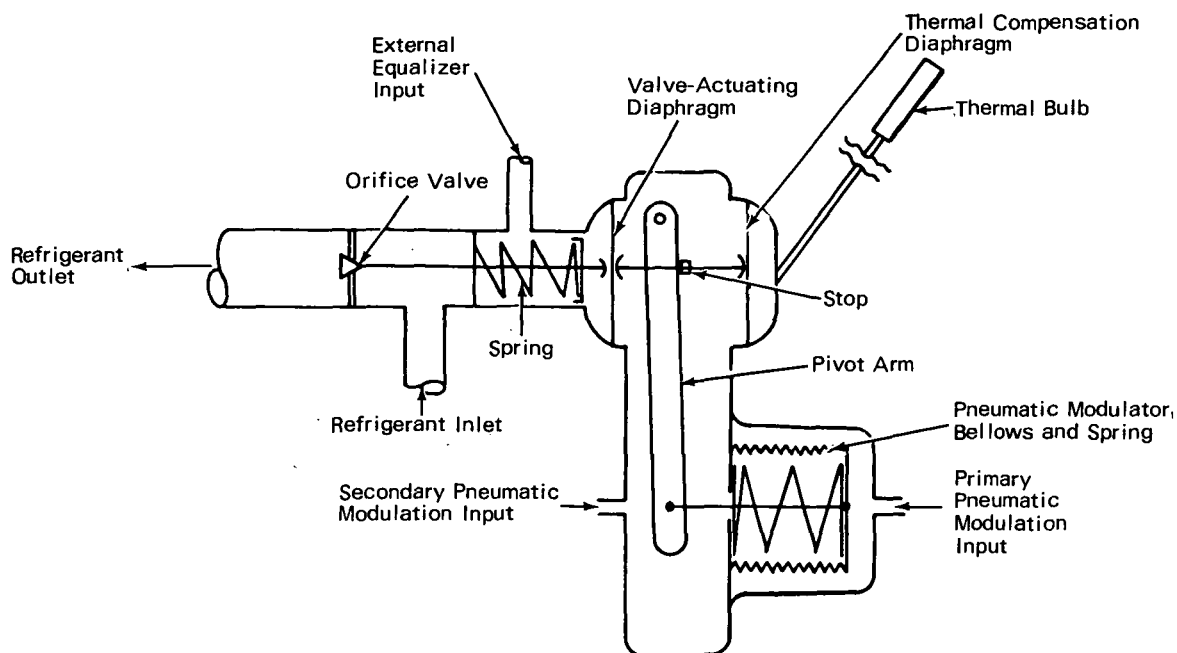
REFRIGERANT THERMOSTATIC EXPANSION VALVE IMPROVED BY DUAL PNEUMATIC MODULATION: A CONCEPT

Standard pneumatic modulating devices used on thermostatic expansion valves can be improved by adding a secondary pneumatic modulation input. Such valves (see fig.) normally meter incoming refrigerant flow through an orifice valve controlled by a valve-actuating diaphragm.

Several forces act on this diaphragm: First, a spring acts to keep the valve closed in the absence of other applied forces. Second, vacuum applied through the external equalizer input acts against the spring to open the valve. Third, pressure derived from a thermal bulb and applied to a thermal-compensation diaphragm presses a mechanical linkage against the opposite side of the valve-actuating diaphragm to open the valve.

Pressure from a suitable pneumatic controller is applied through the primary pneumatic modulation input and acts through a bellows and spring to control the position of a pivot arm. The arm acts against a stop to control the application of the thermal bulb pressure to the actuating diaphragm. The applied pressure is normally modulated, providing a modulated flow through the orifice valve.

Available devices for supplying modulating pressure to the valve include manual pressure regulators, temperature-sensing controllers, pressure-sensing controllers and remotely adjustable (electrical) regulators. Problems arise because sensor-type controllers have no provision for



remote control or adjustment, and manual or remotely adjustable controllers have no sensing capability unless they are used with elaborate electronic equipment. These problems may be solved by connecting a sensor-type controller to the primary pneumatic modulation input, and by connecting another, remotely adjustable controller to the proposed secondary pneumatic modulation input.

Source: G. Pringle of
Chrysler Corp.
under contract to
Kennedy Space Center
(KSC-10072)

No further documentation is available.

VALVE STEM CONNECTOR AND BUSHING

A valve stem connector and bushing prototype provides positive alignment of valve stem and hand wheel stem during valve assembly. After assembly, the connector affords in-service valve stem adjustment with no danger of thread damage. As manufactured, the cast connector coupling halves occasionally failed to form a concentric circle when joined. The bolting action that joins the coupling halves has, in such cases, caused serious damage to the threads of both valve stem and hand wheel stem.

A shaft thimble and redesigned stem connector eliminate direct clamping of the connector to the

valve stem and hand wheel stem. The shaft bushing is screwed onto the stems and the redesigned coupling halves are bolted on to engage the thimble rather than the stem threads. To prevent rotation of the bushing, it is pinned to the connector by a roll pin.

Source: R. E Telle, Jr. of
General Electric Co.
under contract to
Marshall Space Flight Center
(MFS-13756)

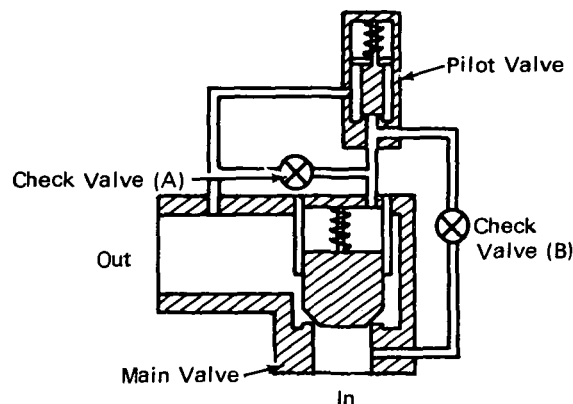
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CHECK VALVES IN PILOT-OPERATED RELIEF VALVE PREVENT REVERSE PRESSURIZATION

Two check valves added to the pilot-operated relief valve (see fig.) control pressure flow to ensure that the piston dome pressure is always at least as great as the main relief valve discharge pressure.

Check valve (A) permits back pressures higher than the inlet pressure to enter the piston dome and thereby keep the main relief valve shut. Check valve (B) prevents this back pressure from entering the inlet of the main relief valve. During normal relief valve operation, check valve (A) prevents the piston dome pressure from bleeding to the discharge pressure.

This modification is fail-safe, since the main relief valve always operates at a pressure no higher than the set pressure, even with the failure of either or both check valves.



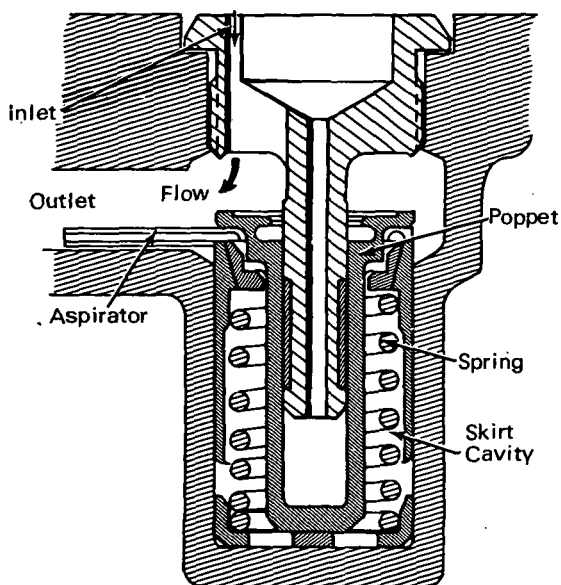
Source: L. Oswalt of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-1925)

No further documentation is available.

ASPIRATOR INCREASES RELIEF VALVE POPPET STROKE

The addition of an aspirator to the relief valve allows poppet inlet dynamic forces to overcome relief valve spring force in such a manner that poppet travel reaches full stroke.

In a relief valve designed as an integral part



of a prevalue, water flow tests proved the design to be inadequate. A flow rate of only 0.36 m³/min (96 gpm) was obtained with 551.6 kN/m² (80 psi) inlet pressure, while the design requirement was for 0.42 m³/min (110 gpm) at this inlet pressure. Analysis established that poppet travel was only 42% of full stroke. The condition was corrected by the addition of an aspirator that provides a relatively low pressure sensing probe for the poppet skirt cavity, thereby reducing the fluid pressure in the skirt cavity and allowing the poppet inlet dynamic forces to overcome the relief valve spring force.

Tests with the aspirator added showed a flow rate increase to 0.55 m³/min (145 gpm) with 551.6 kN/m² (80 psi) inlet pressure, indicating a 100% poppet stroke.

Source: M. E. Biddle of
North American Rockwell Corp.
under contract to
NASA Headquarters
(HQ-77)

No further documentation is available.

LONG-LIFE, LOW-COST BALL VALVE WITH LIFTED SEALS AND CARTRIDGE-TYPE CONSTRUCTION

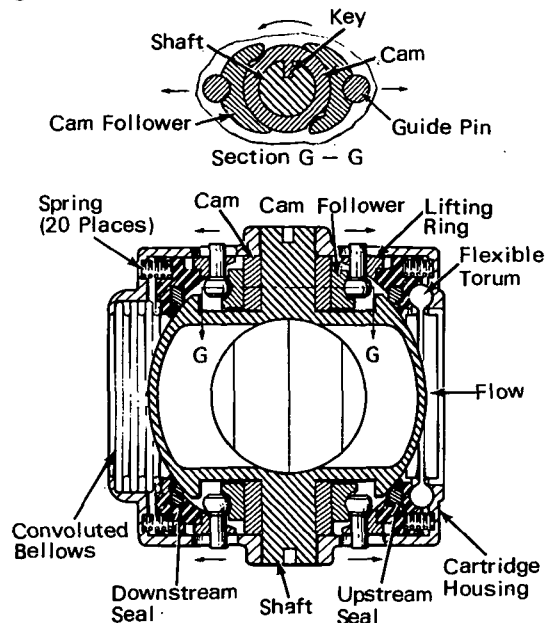
A new ball valve design incorporates a modular construction in an easy-to-install, easy-to-replace cartridge housing, and a system of cams to lift the upstream and downstream seals away from the ball during ball rotation. The concept provides longer valve life and improved seal performance because of less wear on the seals, and less expensive maintenance through easier replacement of the entire assembly. In tests conducted on N_2O_4 , the new valve proved to be more than 200 times more efficient than previous models in preventing leakage.

The ball section of the assembly is integral with an axial shaft and has a central hole which is normal to the shaft. When this hole is in alignment with the two opposing holes in the cartridge housing (see fig.), the valve is open. Inside and around the downstream opening in the housing is a short, convoluted, metallic bellows for absorbing outward movement of the downstream seal. A flexible torus serves the same purpose at the upstream end: to seal between the upstream seal and the housing while permitting outward movement of the seal.

Between the open and closed positions of the valve, the ball rotates $\pi/2$ rad (90°). At the beginning of the "open" rotation, the ball seals are lifted away from the ball by cams on the ball shaft. The cams operate through a system of cam followers, guide pins, and lifting rings surrounding the ball. During the closure rotation, these seals are not moved; i.e., ball-to-seal contact is maintained. When the valve is closed, the ball seals are pressed against the ball by springs and by operational pressure exerted on their exposed areas.

An Oldham-type coupling connects the ball shaft to the valve operating mechanism. This coupling engages keyways in the ball shaft and

the operating shaft, permitting considerable non-alignment between the two. Thus, the cartridge can be easily installed in the valve body without disturbing the assembly or adjusting the operating mechanism.



For high-pressure systems, the torus-bellows system described is recommended. For low-pressure applications, however, the torus and bellows can be omitted, and the ball seals can be replaced with one-piece flexible lip seals. This design costs less to fabricate and is easier to clean.

Source: J. W. Carriker and R. Fieweger of Aerojet-General Corp. under contract to Manned Spacecraft Center (MSC-13430)

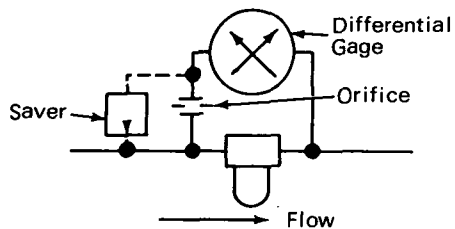
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VALVE LOCKING DEVICE

A locking device provides differential pressure gage protection against surges that frequently occur during system start-up. Gage savers

(clamping devices) were used to isolate gages during surges, but sometimes failed in the closed position, causing a system shut-down that re-

quired maintenance efforts. The new method uses an orifice that is calibrated to restrict system

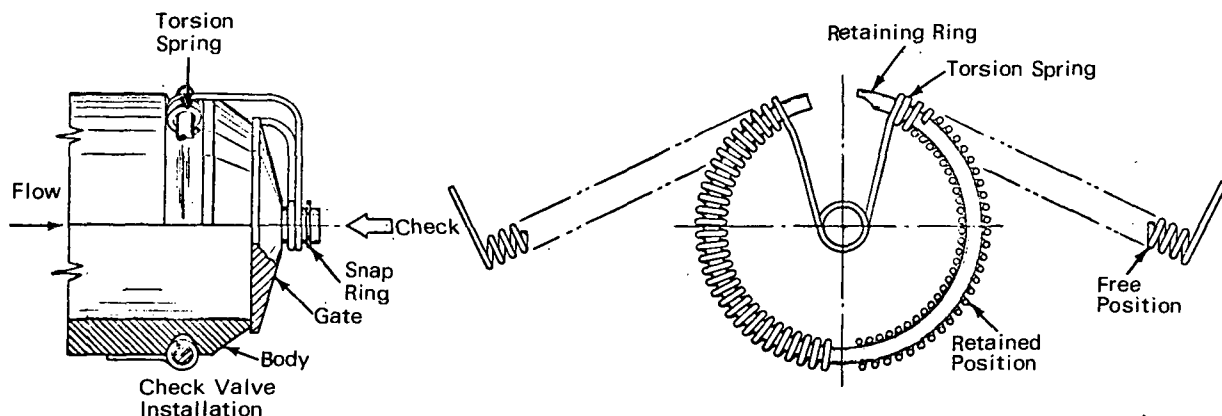


flow to design levels in the presence of surges, but to maintain system operation without stoppage.

Source: G. E. Anderson of North American Rockwell Corp. under contract to Marshall Space Flight Center (MFS-14331)

No further documentation is available.

SIMPLIFIED CHECK VALVE FABRICATION: A CONCEPT



This concept offers a reduction in both fabrication and assembly complexity for valves used in vent or pressure relief applications on low-pressure systems. A toroidal spring (see fig.), used as both hinge and retainer for the valve gate, is secured into an annular groove of the valve body with a retaining ring.

Fluid flow through the valve unseats the gate due to the low-tension characteristic of the

toroidal spring. Any reverse pressure, or a static (no pressure) situation, results in the toroidal spring returning the gate to the closed position.

Source: H. A. Hoche, Jr., of North American Rockwell Corp. under contract to Marshall Space Flight Center (MFS-13793)

No further documentation is available.

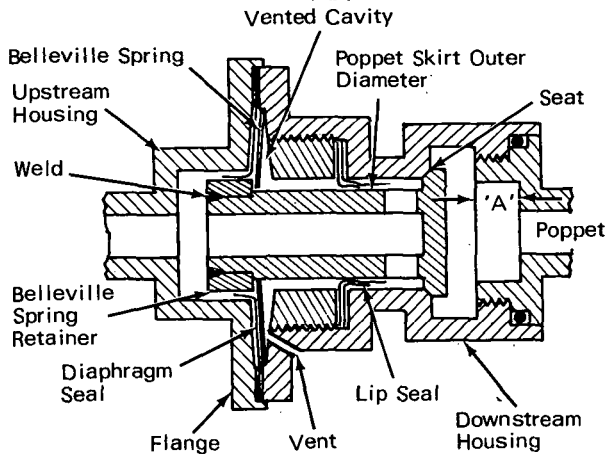
AUGMENTED SNAP ACTION CHECK VALVE: A CONCEPT

This concept involves a check valve in which the poppet area is enlarged and the loading spring has a negative spring rate so that force acting on it from either side causes the spring to pass quickly from the fully-closed to fully-open mode (or the reverse) by an over-center snap action.

The valve (see fig.) consists of a poppet which is held against the seat by a belleville spring. The belleville spring is chosen to have a force-

versus-deflection characteristic or negative spring rate as shown in the graph when used between the closed and open deflections. The vented cavity behind the belleville spring is sealed on the upstream side by a plastic diaphragm seal which is a combination of a diaphragm and a lip seal. The diaphragm portion is clamped at its outer edge between the bolted flanges of the upstream and downstream housings which enclose the valve.

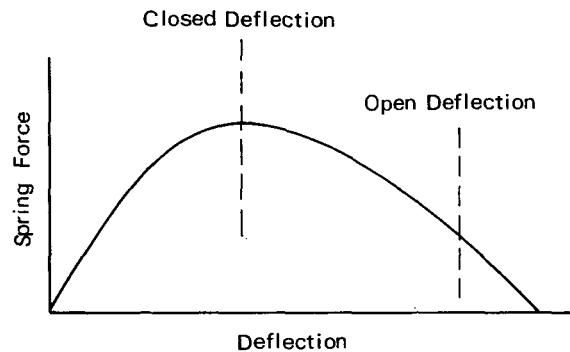
The inner edge is drawn over the cylindrical belleville spring retainer on the poppet. Thus, the belleville spring is sealed at the outer and inner diameters. The vented cavity is also sealed



on the downstream side by a conventional lip seal retained in the downstream housing and sliding on the poppet skirt outer diameter.

In operation, the valve remains closed with a much higher spring force, and therefore seat stress, than in a conventional valve. In the latter, only the poppet area inside the seat diameter is available to be acted on by the pressure which cracks or opens the valve. In the present case, however, the area inside the seat is augmented by the area between the outer diameter of the belleville spring and the poppet skirt outer diameter. Hence, for the same cracking pressure, the augmented valve has a much larger spring force and seat stress.

As the valve starts to open, the spring force decreases in accordance with the graph, and, assuming that a sufficient supply of gas exists to maintain the pressure, the valve snaps fully open.



Similarly, when the pressure drops below the re-seating pressure at which the valve starts to close, the spring force increases and the valve snaps closed.

The addition of a helical spring at "A" improves the spring characteristic and reduces the differential between cracking and reseal pressures.

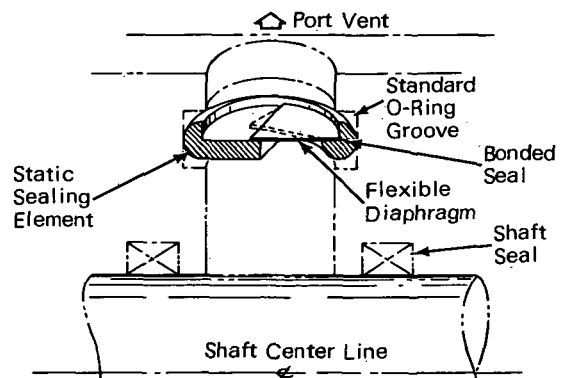
Source: D. F. Ferris of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-19056)

Circle 10 on Reader Service Card.

VENT PORT RELIEF AND CHECK VALVE: A CONCEPT

A conceptual valve would be entirely submerged in the port it controls, and would check the entry of foreign matter into a vent port of a major system, releasing any leakage from the system at a predetermined pressure. The design promises effective protection from mechanical damage experienced by externally-mounted valves. A standard recess is used for positioning and retaining the valve, thereby minimizing weight and space requirements.

A static seal (see fig.) is provided by the O-ring held in a conventional O-ring groove.

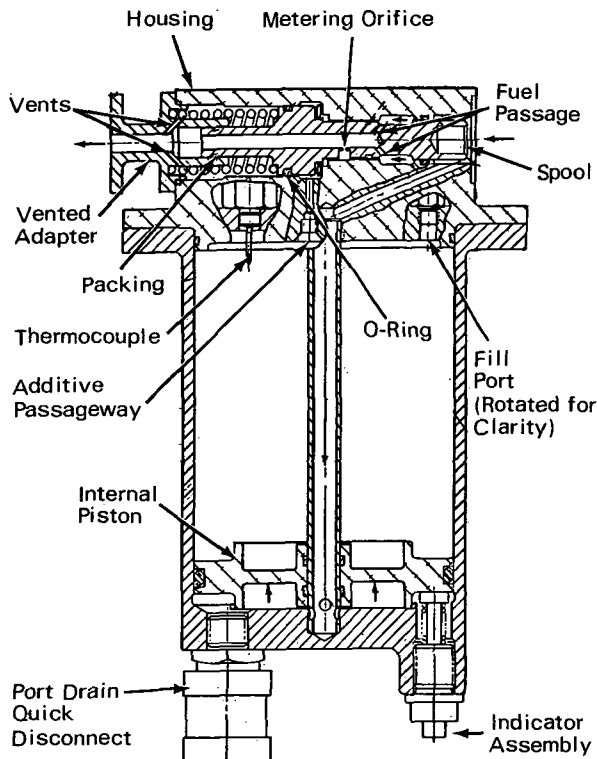


The operational valve element is a flexible diaphragm bonded to the inner periphery of the O-ring, as shown. This element can be molded from a variety of materials such as elastomers, plastics, or numerous metal shim stocks.

Source: H. A. Hoche Jr. of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-13794)

No further documentation is available.

SELF-VENTING FUEL ADDITIVE BLENDER UNIT



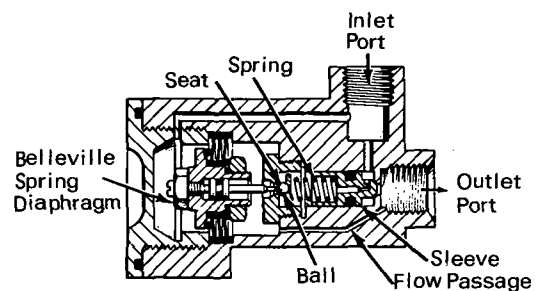
A spool valve, used to blend fuel with a lubricating additive which protects a turbopump, can be modified to remain in the open position when the sealing O-ring fails. The basic unit consists of a housing, a cylinder, a hollow shaft-mounted piston, and a spring-assisted spool. The modification consists of an adapter vented in such a way that leakage of the fuel and additive past the failed O-ring and into the spring cavity will not build up and force the spool to move to the closed position. The system has an approximate 965.3 to 1103.2 kN/m^2 (140 to 160 psig) pressure drop across the unit. By allowing the spring cavity to vent into the discharge line, this pressure drop maintains the spool in the open position in spite of O-ring failure.

Source: E. A. Wolfram of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-14398)

Circle 11 on Reader Service Card.

DUAL RATE PRESSURE RELIEF VALVE

A pressure relief valve vents at a slow bleed rate at one pressure level and at a higher bleed rate at a higher pressure level. The valve housing is bored to receive a sleeve which is free to slide back and forth unrestrained and which closes off or opens a passage between inlet port and outlet port, depending upon its position. An orifice in the sleeve routes the inlet fluid to a ball and seat arrangement which communicates with a flow passage leading to the outlet port. A conventional spring retains the sleeve and the ball/



seat arrangement normally closed. A bellville spring diaphragm assembly attached to a shaft in contact with the ball senses pressure differential between inlet port and outlet port and deflects at a preset inlet pressure to unseat the ball and permit a slow bleed-off to maintain system pressure at the design level. In the event of an inlet pressure surge too great for the ball seat orifice to handle, pressure across the sleeve valve element overcomes the tension in the con-

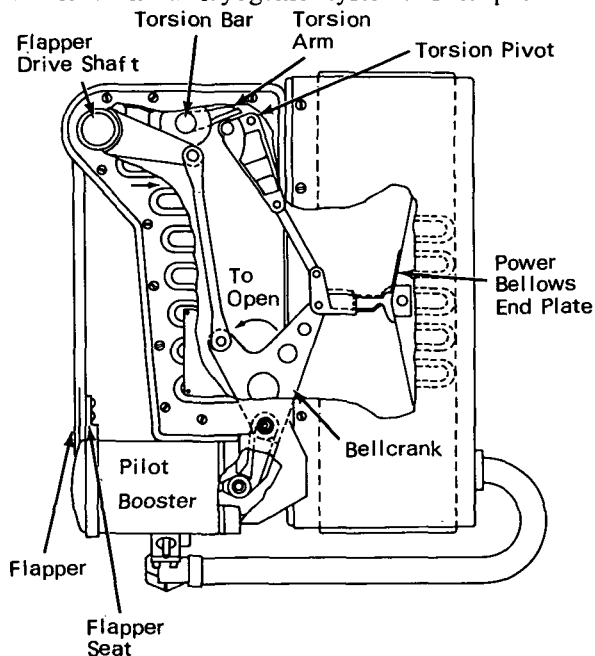
ventional spring to a point that unseats the sleeve valve element, permitting a much greater volume of flow and thus quickly returning system pressure to the design level.

Source: J. Steeneken of
The Garrett Corp.
under contract to
Manned Spacecraft Center
(MSC-11606)

Circle 12 on Reader Service Card.

TORSION BAR PRELOADS VALVE FLAPPER

A torsion bar is used to preload the flapper of a vent and relief valve designed to modulate flow in order to control tank pressure at a preset level in a cryogenic system. This provides



high initial flapper loading and better packaging and weight characteristics than conventional means of preloading.

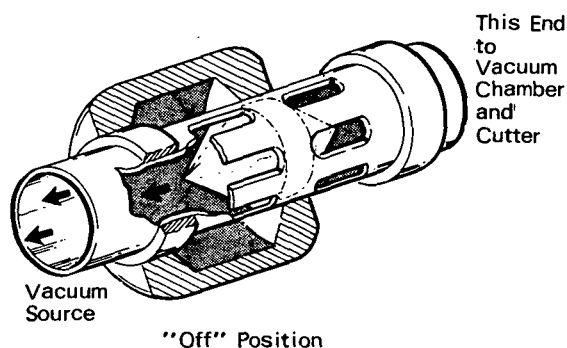
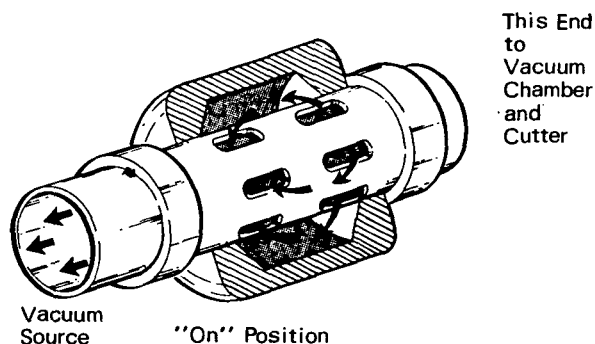
Tank pressure acts directly on the power bellows whose end plate is restrained (see fig.) by tension of the torsion bar (valve end only shown). As tank pressure exceeds the preset level, the power bellows end plate moves left. By means of the bellcrank and linkage, the plate overcomes the torsion bar restraint, simultaneously rotating the flapper drive shaft to unseat the flapper and to lower tank pressure to the preset level. The torsion bar force then acts on the pivoted link to return the power bellows end plate to its original position as bellcrank action reseats the flapper. A pilot booster, directly connected to the power bellows, assists bellcrank rotation in either direction.

Source: D. Marley of
Parker Hannifin
under contract to
Marshall Space Flight Center
(MFS-20636)

Circle 13 on Reader Service Card.

Section 3. Special Purpose Valves

FAST ACTING, HAND-OPERATED VACUUM VALVE WITH POSITIVE SHUTOFF



A new valve provides the high capacity, fast action, and complete shutoff required for operation of a special purpose vacuum-driven hand tool. The tool is a high speed cutter used to make small diameter holes in aluminized plastic insulation blankets. Previous valves did not provide sufficient control while the operator located the tool in place to make the cut. This resulted in prematurely drawing the blanket into the cutter.

The figure illustrates the new valve's simplicity and ease of operator control. By merely sliding the outer member left or right, positive closure and quick, easy opening are achieved. At the same time, the cutter speed can be controlled by holding the outer member in an intermediate position. The new valve also disposes of the waste produced by the cutter, without clogging.

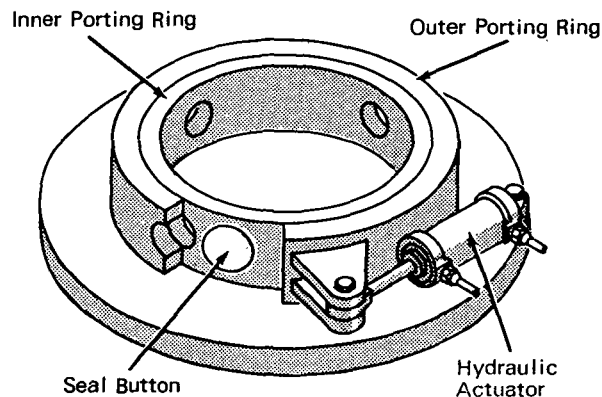
Source: R. A. Farmer of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15783)

No further documentation is available.

SIMPLE, FAST ACTING, FLOW RING VALVE

A simple, reliable quick acting valve for controlling gases or liquids has two porting rings, one within the other, and controls flow by using seal buttons as the sliding valve closers. Multi-porting within the rings allows close control of the gas or liquid flow by the slight rotation of the outer porting ring.

The outer or actuating ring contains plastic seal buttons that are located immediately adjacent to the ports and are flush with the outside surface of the inner porting ring. The seal buttons ride against a plastic coated surface of the inner ring, and are maintained by steel spring washers and the fuel flow pressure acting from behind them.



The respective positions of the inner ring flow ports with the outer ring flow ports or seal buttons determine the amount of flow through the

valve. The outer ring is hydraulically actuated by the gas or liquid of the operating medium and is controlled by a small solenoid valve.

Under test to pressures of 6.895 kN/m^2 (1,000 psi), the valve delivered up to $1.41 \text{ m}^3/\text{min}$ (371 gpm) through 275 cycles with no leakage in any position.

Source: J. A. Lindfors of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-752)

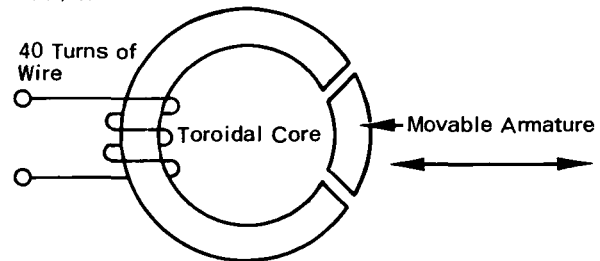
Circle 14 on Reader Service Card.

FERROMAGNETIC CORE VALVE GIVES RAPID ACTION USING MINIMUM ENERGY

This miniature solenoid valve uses advanced ferromagnetic core design to meet rapid-action requirements with a minimum of input energy. With concise packaging, the entire valve, including its energy-storage capacitor and switching electronics, fits into 0.16 cm^3 (1 in.³). The mechanical operation is simple, eliminating part wear and maintenance.

The valve consists of a toroidal core wound with 40 turns of wire. A sector of the core is cut out and mounted on a Be-Cu leaf spring (diaphragm) to serve as a movable armature. This diaphragm also provides the restoring force toward the null position. A 5 mm diameter hemispherical plug, mounted on the armature, seats against an O-ring to form the valve closure. The valve is fed from a $125 \text{ }\mu\text{F}$ electrolytic capacitor, charged to voltages between 20 and 150 V, and switched with a silicon-controlled rectifier.

This valve has been successfully tested through 28×10^6 cycles at a frequency of 100 cycles/sec without seal deterioration. The valve operates on 0.1 J of energy and opens or closes in about 100 μs .



Source: A. V. Larson and J. P. Tinkham of
General Dynamics/Convair Div.
under contract to
Lewis Research Center
(LEW-10135)

Circle 15 on Reader Service Card.

NOVEL VALVE FOR RECIPROCATING COMPRESSORS: A CONCEPT

A thin, ring-type valve that would encircle the cylinder in each of the cylinder inlet and exhaust ports of a reciprocating compressor appears to offer an improvement over conventional spring-loaded poppet valves.

The valve is a thin ring, generally curved in section, that is fitted in a groove around the wall (the inlet or exhaust aperture) and encircles the top of the cylinder wall (Figure A). The inner edge of the inlet valve (and the outer edge of the exhaust valve) is curved into a lip (Figure

B). The outer edge of the inlet valve (and the inner edge of the exhaust valve), straight in section and parallel with the line of the cylinder wall, fits in a guide groove in the wall (Figure C). The valve seats approximately in the middle of its convex side, roughly at $\pi/4$ rad (45°) from the line of the wall. The ring pocket of gas below the opened valve serves to cushion the valve's vertical movement.

As the piston leaves the cylinder head, the lower pressure inside the cylinder opens the inlet

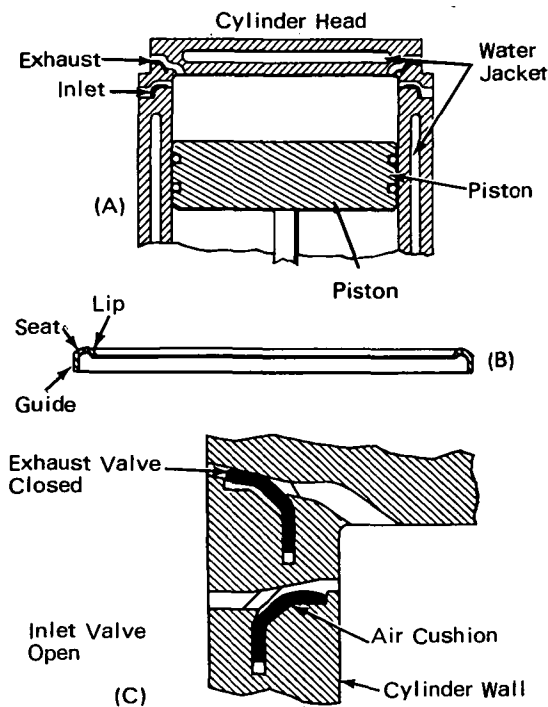
valve. When the piston has half-completed its downward stroke, its velocity and the velocity of the intruding gas are at maximum. The gas velocity over the valve lip lowers the pressure

there and so tends to close the valve during the latter half of the piston's downward travel. During the piston's compression stroke, the exhaust valve acts in a similar fashion.

The behavior and timing of the valve are governed largely by the relation of its design weight to the calculable gas velocity. Because the valve encircles the cylinder, valve lift may be very small relative to valve effective aperture. The valve's smooth contours should make it more than 90% efficient, and stresses generated by its small movement should be negligible. The cylinder head is left free of complications.

The same valve might be used for the inlet of an internal-combustion engine, possibly with these modifications: The valve might be cooled by the injection of cold air into the gas pocket below it; it might be partially shielded during the combustion by a raised periphery of the piston head; or, auxiliary devices might be used to regulate the timing. The peripheral nature of the valve should promote cooling of the cylinder walls. The whole area of the cylinder head would be available for exhaust valves and a spark plug.

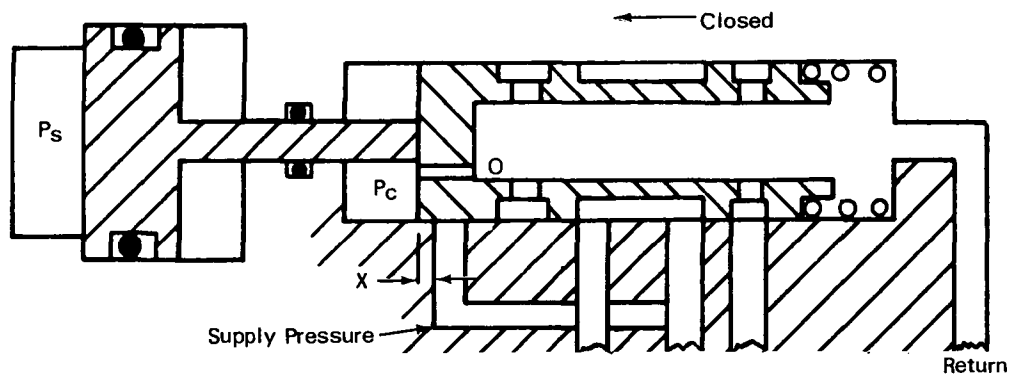
Source: C. E. Wagner of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15060)



(A) Location of Valves in a Compressor.
(B) Vertical Midsection of an Inlet Valve.
(C) Inlet and Exhaust Valves
During Initiation of Induction.

Circle 16 on Reader Service Card.

FAST ACTING, FOUR-WAY SLIDE VALVE



This valve fills the need for a fast-acting, four-way valve that is insensitive to fluctuating sensor pressure.

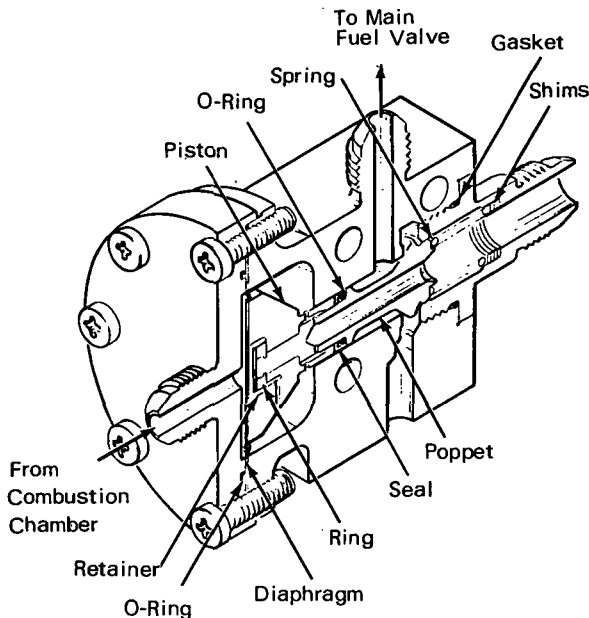
Cavity pressure P_c is maintained at a low level by the combination of overlap X and the size of orifice O . Increasing sense pressure P_s initiates

valve movement against the preloaded spring. An overlap X decrease causes cavity pressure P_c to rise sharply. The opening force on the spool is now greater than the preload on the spring and the valve snaps to full-open position. The valve remains in full-open position until the supply pressure is removed. The spool position is not affected by variations in sense pressure P_s .

Source: M. Kimmel and J. Absalom of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-18608)

No further documentation is available.

NONELECTRIC SIGNAL OPENS FUEL VALVE



Combustion chamber pressure has been used to open the main fuel valve by means of a primary (prevalve) hydraulic valve. Combustion chamber pressure was found to exceed 137.9 kN/m^2 (20 psig) when satisfactory ignition took place.

The pressure developed in the combustion chamber acts directly on the primary valve diaphragm (see fig.) to drive the piston to the right. This overcomes the spring tension, permitting the poppet to move forward and release the hydraulic fluid under constant pressure to the outlet port leading to the main fuel valve actuator.

Source: A. D. Lucci of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-13554)

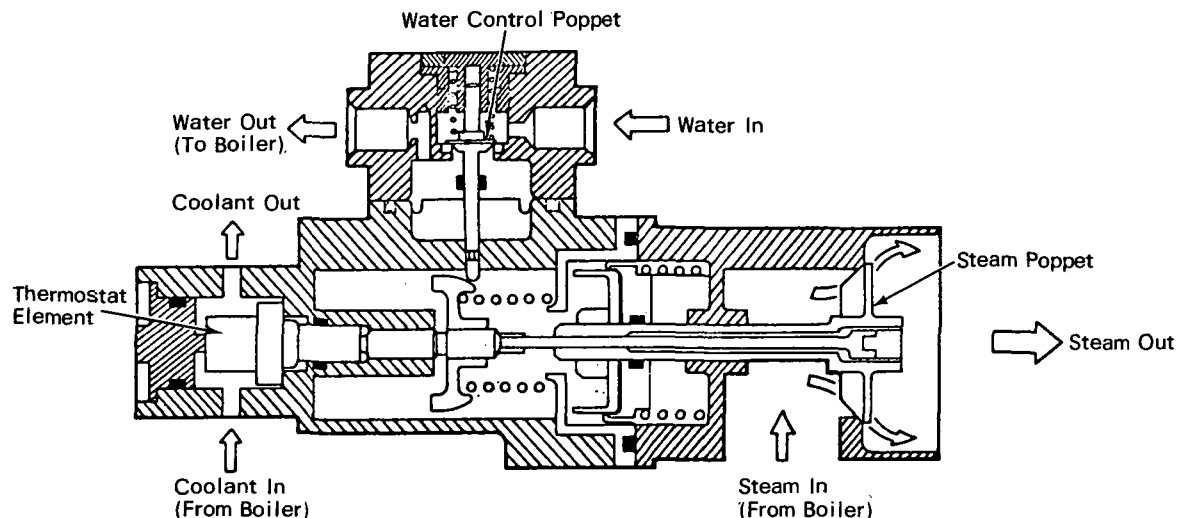
No further documentation is available.

WATER BOILER CONTROL VALVE: A CONCEPT

The conceptual device is intended to provide water flow and temperature control for a small, wick-type water boiler using a single valve. The valve is actuated by a single thermostatic element that senses heat transport fluid outlet temperature; external power is not required.

The valve (see fig.) is actuated as the thermostatic element senses coolant temperature. The control function is as follows: As the coolant temperature increases, the thermostat begins its stroke, opening the steam poppet and reducing pressure in the steam plenum to provide additional cooling to the boiler. As the boiler uses

all the available water in its wicks and storage sponge, the coolant outlet temperature continues to rise and the thermostat increases its stroke. At a preset coolant temperature, the thermostat piston actuates a second valve mechanism, opening the water control poppet and allowing water to flow to the boiler from a pressurized water storage tank. Coolant temperature continues to rise for a few minutes until feed water reaches the wicks and the coolant outlet temperature drops. Steady-state cooling continues until the coolant temperature again increases, at which time the cycle is repeated. The duration of each cycle



is determined by the valve dimensions, boiler characteristics, and size of the boiler sponge reservoir. The amount of sponge used may be varied, and the water on-off valve is independently adjustable, making it possible to change both the cycle time and the control temperature in order to obtain optimum operating characteristics.

Source: G. R. Woods of
Airesearch Mfg. Co.
under contract to
Marshall Space Flight Center
(MFS-14056)

No further documentation is available.

COMPACT, FAST ACTING RELIEF VALVE: A CONCEPT

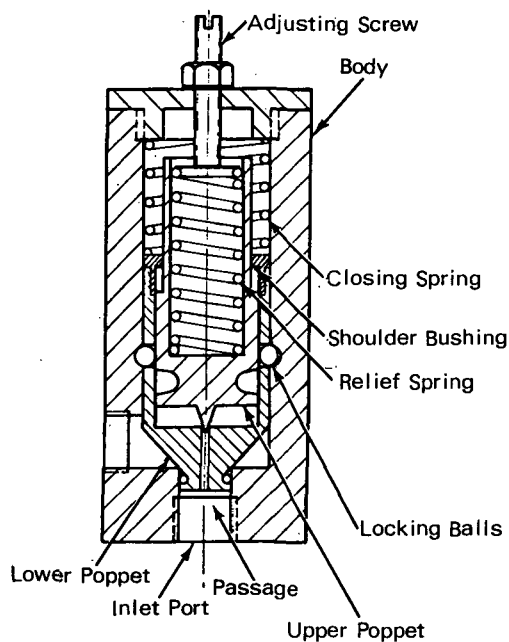


Figure 1

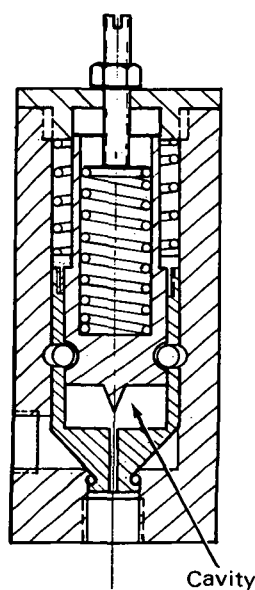


Figure 2

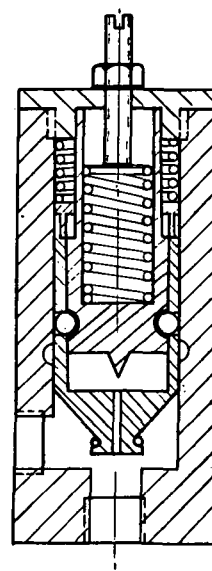


Figure 3

A compact, fast-acting, full-ported, narrow-cracking-band relief valve would remain fully open until system pressure has reduced to a safe pressure before the system can be reactivated. The conceptual valve would be capable of replacing burst diaphragms and would have an automatic resetting feature.

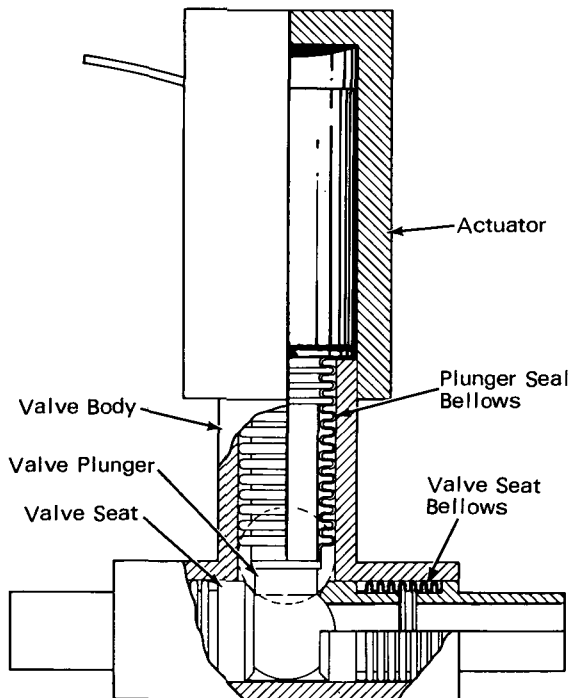
During valve operation, pressure through the inlet port (see Fig. 1) is sensed through the passage in the lower poppet. The upper poppet has a conical nose that opposes the passage pressure, by using the force of the relief spring, until the design pressure has been exceeded. When the design relief pressure is reached, the upper poppet (see Fig. 2) lifts sufficiently to permit pressure buildup in the cavity. The large difference in volume between the passage and the cavity, plus the light tension of the relief spring, causes the upper poppet to move upward very rapidly. When the annular groove in the upper poppet is opposite the locking balls, the lower

poppet is released and is forced upward by system pressure at the inlet port (see Fig. 3). At the end of its stroke, the upper poppet strikes the shoulder bushing, imparting an upward movement to the lower poppet. This impact releases the locking balls by cam action of the locking groove in the valve body. The closing spring forces the lower poppet downward, and the combined force of the two springs determines reseating pressure. The cam action of the ball retaining groove in the upper poppet ensures that the locking balls are returned to the proper position to lock the lower poppet in the closed position.

Source: E. P. Nelson and L. J. Zmuda of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-14158)

Circle 17 on Reader Service Card.

SUBMINIATURE VALVE FOR LIQUIDS OR GASES: A CONCEPT



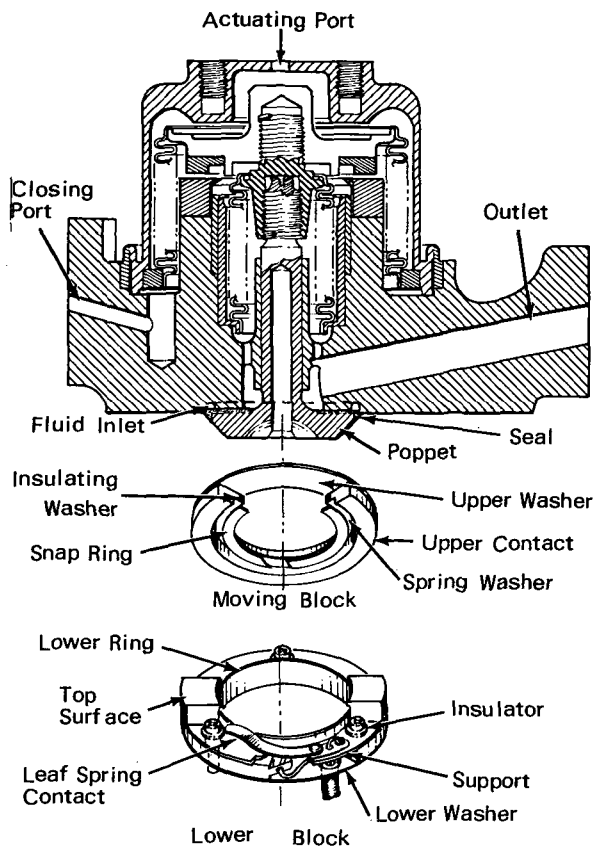
A small, lightweight, two-way valve operates with very low actuating force. The conceptual device was originally designed for use in controlling the carrier gas stream in the gas-chromatography mass-spectrometer system of a spacecraft.

When the valve is in the normally open position, the valve plunger is retracted and free flow is provided from one ball seat aperture to the other. In the normally closed valve position, pressure in the plunger seal bellows forces the plunger down to seat between the two apertures.

Source: A. O. Weilbach of
Bechman Instruments, Inc.
under contract to
NASA Pasadena Office
(NPO-11280)

Circle 18 on Reader Service Card.

FLUID CONTROL VALVE FEATURES INTEGRAL SWITCH



A fluid control valve incorporates a physical stop to complete an electrical circuit and halt poppet travel beyond the desired position. The concept reduced to practice is an integral positive switch control for monitoring poppet travel limit.

The lower block, a stationary stop, is insulated from the rest of the valve. A leaf spring mounted in the lower block extends above the stop surface. This spring is insulated from the block and is connected to a lead to the control circuit. The moving block, which is also insulated and connected to the control circuit, is mounted on the base of the poppet and makes contact with the leaf spring contact when the poppet has reached the design stroke limit. The resultant signal actuates a counter force through the closing port, and the valve is held where desired and free of chatter.

Source: A. P. Swift of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-14081)

Circle 19 on Reader Service Card.

REACTION CONTROL SYSTEM FUEL DISPOSAL VALVE

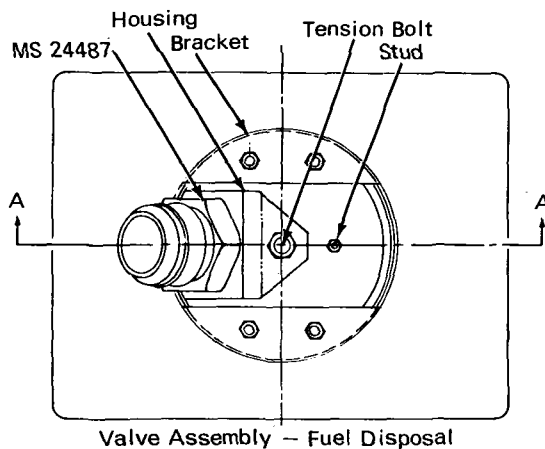


Figure 1.

A valve which dumps reaction control system fuel during a space flight abort could also be used in industry as a relief (safety) valve in heavy duty, high pressure boilers and storage tanks.

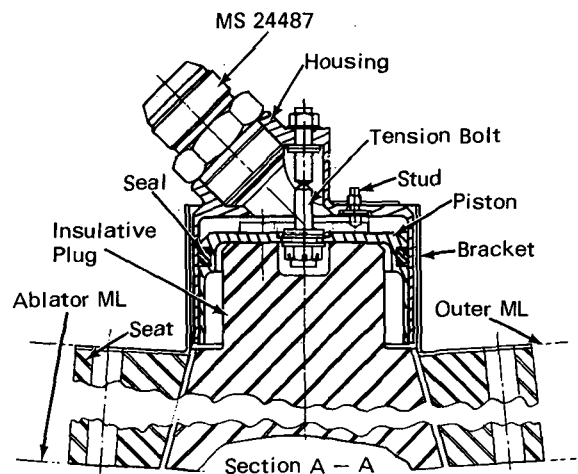


Figure 2.

The valve consists mainly of a combination piston and frangible plug arrangement and, although a one-shot device, can be easily replaced.

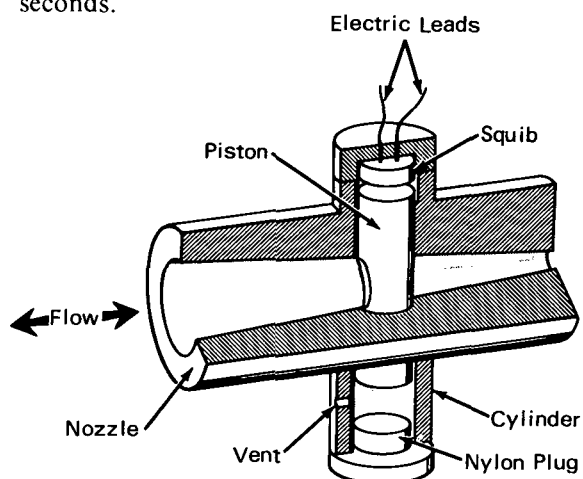
The fuel under pressure is released to the valve by firing two squibs (not shown). The pressure loading that results when the fuel reaches the valve piston ruptures the tension bolt and ejects both the piston and frangible plug as a unit. The housing is the main body of the valve; the stud is nonstructural and is used to index the piston and frangible plug assembly in proper position.

Source: E. L. Confer of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-11623)

No further documentation is available.

QUICK-CLOSING VALVE ACTUATED BY EXPLOSIVE CHARGE

A plug-type valve, remotely actuated by a commercially available, electrically initiated squib of low explosive power, can shut off a high-pressure 31,697 kN/m² (4600 psi), high-temperature 5811 K (10,000° F) gas flow in a few milliseconds.



The valve incorporates a piston inserted with a light interference fit into a cylindrical bore extending transversely through the flow nozzle.

The piston has a radial hole which is concentrically aligned with the axis of the nozzle to provide unobstructed flow when the valve is in the open position. The squib is mounted at a small standoff in a cap above the top of the piston. When the flow is to be shut off, the squib is initiated from a remote voltage source. The resulting detonation drives the piston down the cylinder until it is stopped by the nylon plug. In this closed position, the piston provides a tight seal against the gas flow. Time for complete closure after initiation of the squib is 6 to 8 msec.

This valve has been used for quick shutoff operation only. Valves of this type can also be designed for remote reverse actuation by mechanical, hydraulic, or explosive means. More rapid closure is attainable with squibs containing heavier explosive charges.

Source: S. J. Majeski
Ames Research Center
(ARC-55)

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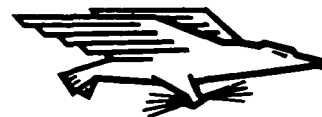
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